III. SURFACE WATER ASSESSMENT

A. SURFACE WATER MONITORING PROGRAMS

The Office of Water Resources' (OWR) surface water monitoring program is designed to gather state-wide baseline data in addition to targeted monitoring information. The data is used in establishing and reviewing the state's water quality standards, to measure progress toward achieving the state and federal water quality goals, and to supply information for use in development of permit limits for wastewater discharges. Current surface water monitoring programs include activities conducted by the OWR staff as well as monitoring carried out by other agencies/organizations under contracts with OWR. The surface water monitoring program consists of targeted and probability based station sites, intensive surveys, special studies, and volunteer monitoring programs.

1. Beach Monitoring Program

There were 115 bathing water facilities licensed with the Department of Health (DOH) in 1998 and 1999. Of the 115 licensed facilities, 80 were tested for fecal coliform by DOH staff or the facilities' staff. The DOH determined that the remaining 35 bathing water facilities could be exempted from testing requirements based upon the waterbodies' profile evaluations, past test results, and test results from DEM's shellfish water quality monitoring of waters in close proximity to these bathing areas. In addition, DEM now conducts the monitoring at the state-owned freshwater bathing areas. Results are compared with the state's water quality standards for swimming, the fecal coliform standards for Class B and Class SB waters. Any beaches exceeding the criteria are resampled on a second date. DOH is responsible for making the decision to close any beach due to high fecal coliform counts.

On June 16, 1998 the state experienced an unusually heavy rain event which caused 175 million gallons of sewage to be discharged into Narragansett Bay via combined sewer overflows. This caused DOH to close 9 saltwater beaches for a period between 1 day at some sites to almost 1 month at other sites. On August 3, 1999, the DOH issued a swimming advisory warning the public of the risk of getting swimmer's itch when swimming at the Barrington Town Beach. This advisory continued throughout the remainder of the of the summer season.

2. Shellfish Growing Area Monitoring

The Shellfish Growing Area Monitoring Program is part of the State of Rhode Island's agreement with the USFDA's National Shellfish Sanitation Program (NSSP). The purpose of this program is to maintain national health standards by regulating the interstate shellfish industry. The NSSP is designed to oversee the shellfish producing states' management programs and to enforce and maintain an industry standard. As part of this agreement, the State of Rhode Island is required to conduct continuous bacteriological monitoring of the shellfish harboring waters of the State to maintain certification of these waters for shellfish harvesting for direct human consumption. Shoreline surveys are an additional requirement of the NSSP (see below). Rhode Island collects samples from 17 separate shellfish growing areas and analyzes for total and fecal coliform bacteria. These growing areas encompass all of Narragansett Bay and its shellfish harboring tributaries, all the south shore coastal salt ponds, Little Narragansett Bay, and Block Island. Each of the 17 growing areas incorporate

anywhere from 9 to 39 fixed sampling stations.

Water samples are collected monthly at the 9 stations in the Upper Narragansett Bay, the 16 stations in the Warren and Barrington Rivers, the 19 stations in Greenwich Bay, the 10 stations in the Kickamuit River, and the 16 stations in Mt. Hope Bay, when those conditionally approved areas are open for shellfish harvesting. The results are used to manage those conditionally approved shellfish growing areas. The other shellfish growing areas in Rhode Island are not subject to the volume and number of sewage discharges that affect the Upper Narragansett Bay or the predictable nonpoint source impact that affects the Warren and Barrington Rivers, Greenwich Bay, the Kickamuit River and Mt. Hope Bay. Accordingly, these other shellfish growing areas are monitored less frequently. Prior to March 1981, there was no regular schedule for sampling these other areas. Sampling in a particular area was done as an intensive survey on an infrequent basis. In March 1981, the sampling program was expanded and has continued through present. The emphasis has shifted to a trend-oriented monitoring program. At present, those growing areas that are approved for shellfish harvesting are sampled a minimum of six times a year. An attempt is made to sample growing areas that are prohibited to shellfish harvesting a minimum of once a year.

A PSP (paralytic shellfish poisoning) sampling program begins in April and runs through October. There are three primary monitoring and five secondary stations. Shellfish samples are collected by RIDEM/Division of Fish and Wildlife and sent to the RIDOH laboratory for analyses. If elevated PSP levels are detected at any of the three primary stations, RIDOH contacts DEM, and samples are then collected from all eight stations. The three primary stations are located at the mouth of the Sakonnet River and the entrances to East and West Passage of Narragansett Bay.

The Rhode Island Department of Health/Division of Food Protection and Sanitation monitors and collects weekly samples from shellfish establishments in the interstate shellfish program, plus routine market samples for bacteriological testing. Furthermore, bacteriological and heavy metal analyses are performed by RIDOH on shellfish tissue from fourteen monitoring stations in the bay. These fourteen stations are:

1. Providence River (North of Bullocks Point)
2. Providence River (Western Side)
3. Providence River (Eastern Side)
4. Longmeadow (Upper Bay)
5. Base of Warren River (Upper Bay)
6. Touisset Point (Mt. Hope Bay)
7. Ohio Ledge (Upper Bay)
8. College Area (Roger Williams) (Mt. Hope Bay)
9. Mount View, North Kingstown (West Passage)
10. Tank Area, Mt. Hope Bay

11. East Passage (Between Hog Island and Coggeshall Point)
12. Wickford (Breakwater Area)
13. Potters Cove
14. Sakonnet River (Portsmouth Park Area)

All data for these latter two programs (PSP and shellfish meat analyses) are maintained by the Rhode Island Department of Health, Division of Food Protection and Sanitation.

3. Shoreline Surveys

Shoreline surveys are an additional requirement of the National Shellfish Sanitation Program (NSSP). These surveys are necessary to determine shellfish classification in a particular growing area and to locate all actual and potential bacterial sources. Such surveys involve an intense examination of the shoreline to identify all running pipes and tributaries for bacteriological quality as well as calculating flow rates, and then evaluating the impact upon specific growing areas. Inactive pipe sources and drainage ditches are also documented for future reference and evaluation. A shoreline survey must be performed every three years for each approved and conditionally approved growing area to meet NSSP criteria. Annual shoreline survey updates are also required each year for all approved and conditionally approved growing areas to ensure they are appropriately classified and to re-evaluate pollution sources previously identified. Water quality statistical analyses from routine sampling runs are required in conjunction with the status of any pollution sources identified during previous shoreline surveys. The Shoreline Survey Program is discussed in more detail in Chapter H – Public Health/Aquatic Life Concerns.

4. USGS Monitoring Fixed Stations

The Office of Water Resources has contracted with the U.S. Geological Survey (USGS) to conduct riverine monitoring in Rhode Island. Samples are collected at 7 stations described below.

Site	River	Location.
1	Blackstone	Blackstone R. at Millville, MA.
2	Branch	Branch R. at Forestdale, RI
3	Blackstone	Blackstone R. above Manville Dam
4	Pawtuxet	Pawtuxet R. at Cranston RI
5	Pawtuxet	Pawtuxet R. at Pawtuxet, RI
6	Pawcatuck	Pawcatuck R. at Westerly RI
7	Taunton	Taunton River at East Bridgewater, MA

All of the results are published in the U.S. Geological Survey publications, "Water Resources Data: Massachusetts and Rhode Island," on an annual basis. Table 3A-1 lists the analyses performed and the sampling frequencies

5. Chemical Baseline Monitoring

In 1991, to supplement the limited number of river stations monitored, RIDEM developed a cooperative agreement with URI's Civil and Environmental Engineering Department to conduct a study establishing a baseline monitoring program for the rivers of RI. During 1991, 1993, 1996, 1998 and 1999 approximately twenty-five stations (Table 3A-2), selected from the forty-five Rapid Bioassessment Protocol (RBP) biological stations (see section III.A.7.c. below), have been monitored under this program. Water quality samples from these 25 locations are collected on a quarterly (seasonal) basis. The grab samples are analyzed for trace metals, nutrients, BOD_5 and other parameters (Table 3A-3). Funding problems prevented the development of a cooperative agreement with URI for this monitoring program in 1995 and 1997. Fortunately a long term agreement and funding are now in place for this project and consistent sampling of these 25 sites started in 1998.

The 25 stream stations monitored have afforded at least a limited baseline snapshot of water quality conditions where data was previously lacking. In addition, this program has allowed for a comparison of chemical water quality data with the biological assessment information from the RBP study, at these 25 sites.

Table 3A-1 Parameters measured at USGS Fixed Stations

MEASURED QUARTERLY
WATER COLUMN SAMPLING

Field determinations
- Streamflow
- Water temperature
- Specific Conductance
- pH
- Dissolved oxygen
- Alkalinity

Biological characteristics
- Fecal coliform bacteria
- E-Coli

Major nutrients

Nitrogen
- Dissolved nitrite
- Dissolved nitrate
- Dissolved $NO_2 + NO_3$
- Dissolved ammonia

Phosphorus
- Total Phosphorus
- Total orthophosphate

5 day biochemical oxygen demand (BOD)

Total Organic Carbon (TOC)

Suspended Sediments

Trace Elements

Total manganese	Total arsenic	Total iron	Total mercury
Dissolved selenium	Dissolved zinc	Total aluminum	Dissolved lead
Dissolved silver	Dissolved cadmium	Dissolved copper	Dissolved nickel
Dissolved chromium	Dissolved molybdenum		

MEASURED TWICE YEARLY
WATER COLUMN SAMPLING

Common constituents

Dissolved calcium	Dissolved chloride	Dissolved potassium	Dissolved sodium
Dissolved magnesium	Dissolved sulfate	Dissolved fluoride	

Other Constituents

Color COD Phenols, total Turbidity

ROE at 105 °C total and suspended

MEASURED ONCE YEARLY DURING PERIODS OF LOW STREAM FLOW
STREAM BOTTOM SEDIMENTS

Organic compounds

Total aldrin	Total dieldrin	Total DDD	Total DDE
Total DDT	Total endosulfan	Total endrin	Total PCB
Total PCN	Total lindane	Total heptachlor	Total mirex
Total methoxychlor	Total perthane	Total toxaphene	Total chlordane
Total heptachlorepoxide			

TABLE 3A-2 STREAM SAMPLING SITES FOR 1992 - 1998 RWU/URI

BIOLOGICAL AND CHEMICAL MONITORING

			BIOLOGICAL MONITORING							CHEMICAL MONITORING				
STREAM	TOWN	SAMPLING LOCATION	92	93	94	95	96	97	98	91	93	96	97	98
Abbot Run Brook (No)	Cumberland	Route 120	x	x	x	x	x	x	x	*	*	*	*	*
Abbot Run Brook (So)	No. Attleboro	Valley Rd.	x	x	x	x	x	x	x	*	*	*	*	*
Adamsville Brook	Adamsville	At USGS gage on Rt. 81 (Crandall Rd)	x	x	x	x	x	x	x	*				
Ashaway River	Hopkinton	At Rt. 216 below bridge	x	x	x	x	x	x	x	*	*	*	*	*
Bailey's Brook	Middletown	Kempenaar's Clambake (private rd)	x	x	x	x	x	x	x	*	*	*	*	*
Beaver River	Richmond	Shannock Hill Rd.	x	x	x	x	x	x	x	*	*	*	*	*
Big River	W. Greenwich	South side of Rt 3	x	x	x	x	x	x	x	*	*	*	*	*
Blackstone River	Lincoln	Below Manville Dam	x	x	x	x	x	x	x					
Buckeye Brook	Warwick	Rt 117A at Lockwood Corner	x	x	x	x	x	x	x					
Bucks Horn Brook	Coventry	At Lewis Farm Rd	x	x	x	x	x	x	x	*	*	*	*	*
Canonchet Brook	Hopkinton	Woodville\Alton Rd	x	x	x	x	x	x	x	*	*	*	*	*
Carr River	W. Greenwich	Burnt Saw Mill Rd	x	x	x	x	x	x	x					
Chipuxet River	Exeter	Wolf Rocks Rd	x	x	x	x	x	x	x	*	*	*	*	*
Clear River	Burrillville	Victory Highway	x	x	x	x	x	x	x	*	*	*	*	*
Cold Brook	Little Compton	Pottersville Road	x	x	x	x	x	x	x					
Congdon Brook	W. Greenwich	At south side of bridge near old foundation	x	x	x	x	x	x	x					
Dolly Cole Brook	Foster	Old Danielson Pike	x	x	x	x	x	x	x					
Dundery Brook	Little Compton	Swamp Road	x	x	x	x	x	x	x	*	*	*	*	*
Fall River	Exeter	North of Route 165	x	x	x	x	x	x	x	*	*	*	*	*
Hardig Brook	Warwick	Toll Gate Rd near Little Gorton Pd	x	x	x	x	x	x	x		*	*	*	*
Hemlock Brook	Foster	150 m W of Hemlock Rd bridge	x	x	x	x								
Hunt River	E. Greenwich	Route 1	x	x	x	x	x	x	x	*	*	*	*	*
Jamestown Brook	Jamestown	Watson Farm Road	x	x	x	x	x	x	x	*	*	*	*	*
Keech Brook	Burrillville	At covered bridge in Geo. Washington Mgmt. Area	x	x	x	x	x	x	x	*	*	*	*	*
Kickamuit River	Swansea,MA	At Poverty Corner Road		x	x	x	x	x	x					
Lawton Valley Brook	Portsmouth	Below Newport Res. Off Rt 114		x	x	x	x	x	x					
Maidford River	Middletown	Prospect Avenue	x	x	x	x	x	x	x	*	*	*	*	*
Maskerchugg River	E. Greenwich	Route 1 before Goddard Park								*	*	*	*	*
Meadow Brook	Richmond	Pine Hill Rd (Carolina Management Area)	x	x	x	x	x	x	x	*	*	*	*	*
Moosup River	Coventry	At Rt 14 Bridge				x	x	x	x					
Moswansicut Brook	Scituate	Near Rt. 116, west 80 m - below old stone bridge	x	x	x	x								
Nipmuc River	Burrillville	South of Brook Road - Top Brk. Below pool	x	x	x	x	x	x	x					
Nooseneck River	W. Greenwich	West side of Rt 3	x	x	x	x	x	x	x					
Palmer River	Rehoboth,MA	At County Street				x	x	x	x					
Parris Brook	Exeter	Blitzkreig Trail	x	x	x	x	x	x	x	*	*	*	*	*
Pascoag River	Burrillville	Grove St. bridge	x	x	x	x	x	x	x	*	*	*	*	*
Pawcatuck River	Westerly	Below White Rock Bridge		x	x	x	x	x	x					
Pawtuxet River	Cranston	At USGS gage in Cranston	x	x	x	x	x	x	x					
Queens River	Exeter	Liberty Road	x	x	x	x	x	x	x	*	*	*	*	*
Round Top Brook	Burrillville	Brook Road	x	x						*	*	*	*	*
Runnins River	Seekonk	At Rt 44 bridge		x		x	x	x	x					
Rush Brook	Scituate	100 m W of Elmdale Bk	x	x	x	x								
Saugatucket River	Wakefield	Rt 1A bridge	x	x	x	x	x	x	x					
Silver Creek	Bristol	At Chestnut Street		x	x	x	x	x	x					
Swamp Brook	Scituate	15 m NW of inflow pt. of Ponaganset Rv. into Scituate Res.	x	x	x	x								
Ten Mile River	E. Providence	Broadway Bridge	x	x	x	x	x	x	x					
Tomaquag Brook	Hopkinton	Chase Hill Rd	x	x	x	x	x	x	x	*	*	*	*	*
Wilbur Hollow Brook	Scituate	3 m N of culvert crossing on Old Plainfield Pike	x	x	x	x								
Wood River	Richmond	North of Skunk Hill Rd off Old Nooseneck Road	x	x	x	x	x	x	x	*	*	*	*	*
Woonasquatucket River	Providence	Eagle Street Bridge	x	x	x	x	x	x	x					

TABLE 3A-3

PARAMETERS MEASURED QUARTERLY BY URI AT BASELINE MONITORING SITES

Dissolved Oxygen (DO) (quarterly + (1) 48h survey in Summer 1991)
pH
Total Hardness
Specific Conductance (quarterly + (1) 48h survey in Summer 1991)
Temperature (quarterly + (1) 48h survey in Summer 1991)
Instantaneous Flow
Total Coliform
Fecal Coliform
Fecal Streptococci
BOD_5
(NO_2+NO_3) (Diss)
NH_4
Ortho. P (Diss)
Total P
Na (Diss)
Cl (Diss)
Volatile Suspended Solids
Total Cu
Total Cd
Total Pb
Total Fe

6. Biological Monitoring

a. General

The importance of biological assessments in the evaluation of water quality has long been recognized in Rhode Island. Biological assessments are evaluations of the biological condition of waterbodies using biological surveys and other direct measurements of resident biota in surface waters. Biological assessments are used to supplement physical and chemical water quality monitoring data. More specifically, the biological data can be used to identify long-term trends in water quality which reflect water pollution abatement efforts and/or needs. The survival of a species or aquatic community is dependent upon favorable instream environmental conditions. The effects of pollutants are evidenced in the population of organisms, species composition and diversity, and the physiological condition of natural aquatic communities.

The RIDEM, DWR uses two types of biological monitoring programs. Multiple plate artificial substrates have been used to evaluate the biological community in deep rivers since 1974. In addition, EPA's Rapid Bioassessment Protocol (RBP) has been used since 1991 for the assessment of the biological integrity of various shallow river sites in the state.

b. Artificial Substrate Monitoring

The Fullner multiple-plate artificial substrate with 14 plates has been used by DWR for over 20 years to assess instream biological communities. Stations selected for this biological monitoring include those used for USGS trend chemical sampling (Table 3A-4). The purpose of this was to more closely relate chemical and biological data. This method has the advantage of providing a uniform sampling habitat for each station, thus reducing the problem caused by varying types of river bottom and depth.

Macroinvertebrates (mostly aquatic insect larvae) collected on the artificial substrates are classified according to their tolerance of pollutants. For the Division's biological analyses, organisms were counted and placed in one of the three categories described below:

1. Tolerant - Organisms frequently associated with gross organic contamination and generally capable of thriving under periods of anaerobic conditions, some even in the presence of toxic wastes.

2. Facultative or Intermediate - Organisms having a wide range of tolerance and frequently associated with moderate levels of organic contamination.

3. Intolerant or Sensitive - Organisms that are not found associated with even moderate levels of organic contaminants and generally intolerant of even moderate reductions in dissolved oxygen.

Table 3.A-4 Biological River Stations (1998-1999)

BRANCH RIVER

Forestdale, Rt. 146A

BLACKSTONE RIVER

Rt. 122, Millville, MA

Manville Dam

PAWTUXET RIVER

Cranston Gage

Pawtuxet Village, Rt. 1A

PAWCATUCK RIVER

Westerly Gage

CONTROL

Wood River, Skunk Hill Rd.

c. Rapid Bioassessment Protocol Monitoring

The Rapid Bioassessment Protocol (RBP) involves an integrated assessment, comparing habitat (physical structure, flow regime) and biological measures with defined reference site conditions. EPA originally designed these protocols as inexpensive screening tools to determine if a stream is supporting or not supporting a designated aquatic life use. However, the protocol are now considered applicable to a wider range of planning and management purposes. They may be appropriate for priority setting, point and nonpoint source evaluations, use attainability analyses, and trend monitoring.

Since 1992, a network of 45 stream riffle-area sites (Table 3A-2) have been surveyed by Roger Williams University in cooperation with and contracted by RIDEM. Each site is visited during the spring-summer season and

macroinvertebrates are sampled (minimum 100 organisms per site visit where feasible). Data are analyzed using RBP I and II protocol which include varying degrees of field and laboratory organism identification.

The streams sampled within the state range in stream order from first order to fifth order. Eight of the streams are considered to be first order, eighteen second order, 12 third order, four fourth order and three are of the fifth order. Lower order streams are quite dependent upon the immediate characteristics of the watershed. In other words, runoff is a direct-affect component versus one of many components within a higher order stream. It is important to note that the 1993, 1995 and 1997 sampling events were during drought conditions which may have resulted in fewer riffles, lower dilution and lack of runoff. This probably affected the types of organisms collected and resulted in an altered picture of the stations based on the metrics, from that seen in other years. This information was taken into account during the evaluation of the biological assessments.

Initial bioassessment work involved establishing and field testing the Rapid Bioassessment Protocols in Rhode Island streams and rivers. Fall River was selected as the reference station in 1992, however, further evaluation has resulted in using the Wood River station as the reference site since 1993. In addition, refinement of the protocol over the past 4 years has established the presence of two sub-ecoregions within the state: coastal areas and inland areas. Incorporation of the presence of these two sub-ecoregions into selection of reference sites and application of the protocols will continue.

The habitat and physical parameters and biological metrics of each station were compared to those of the selected reference station and given an overall bioassessment score. The bioassessment categories include:

(1) nonimpaired - Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure and optimum community structure for the stream size and habitat quality.

(2) slightly impaired - Community structure less than expected. Species composition is lower due to the loss of some intolerant forms. Percent contribution of tolerant forms increases.

(3) moderately impaired - Consists of fewer species due to loss of most intolerant forms.

(4) severely impaired - Few species present and often dominated by one or two species.

7. Long-term Monitoring of Narragansett Bay Watershed

The Narragansett Bay Estuary Program has the duty and responsibility within RIDEM to coordinate implementation of the Narragansett Bay Comprehensive Conservation and Management Plan (CCMP). The Management Plan emphasizes the importance of development of a long term monitoring program on the Bay, and includes

in its objectives the pursuit of monitoring which addresses the following issues:

- Detecting long-term changes in the functioning of the Bay ecosystem.
- Assessing the influence of changing anthropogenic pollutant loadings and the success of management actions.
- Establishing baseline data to detect events such as fisheries collapse and algal blooms and their interactions with ecological disturbances.
- Provide a framework to support on-going Bay Research

In recent years, monitoring efforts beyond the shellfish bacterial monitoring in the Bay have been limited to select subareas of Narragansett Bay based on limited, area-specific grant funding. Examples include the EPA funded Providence-Seekonk River TMDL Total Maximum Daily Loadings study and the National Oceanic and Atmospheric Administration (NOAA) - URI Sea Grant Greenwich Bay Initiative. However, thanks to seed money provided to RIDEM by Sen. John Chafee of the R.I. Congressional delegation, a multi-partner Bay-wide monitoring system has been developed through collaboration among URI, EPA, NOAA National Marine Fisheries Service (NMFS), and RIDEM. A grant totaling $1.5 million for monitoring work on Narragansett Bay and other R.I. marine waters provides the first steps towards a comprehensive continuous monitoring system.

Over the last two years, the Narragansett Bay Estuary Program has aided in the technical planning and design of this state-of-the-art continuous monitoring system for all of Narragansett Bay. A technical steering committee oversees the project development, and includes scientists from NOAA/NMFS Narragansett & Woods Hole, URI Graduate School of Oceanography (GSO), and RIDEM. Portions of this bay-wide water quality monitoring system are based on the NBEP's Comprehensive Long-Term Monitoring Plan (Narragansett Bay Monitoring Plan Final Report to the NBP, June, 1992).

The in-Bay components of the monitoring system include at least 3 major efforts:

1. A monthly survey of the zooplankton (tiny floating animals critical to the food chain) in the Bay using an advanced computer-controlled shuttle towed behind a boat. The device can move up and down the water column, sampling zooplankton while simultaneously measuring depth, salinity, temperature, dissolved oxygen (D.O.), pH, and chlorophyll *a* as a tow boat covers set transects of the Bay. The present transect layout covers the Providence River, Upper Bay, Mount Hope Bay, and the East and West Passages.
2. Continuous water quality monitoring stations at 7 sites strategically selected around the Bay to provide a good picture of the overall health of the Bay. These stations will have continuous monitoring probes set at several depths measuring salinity, temperature, D.O., pH, tide height, and, for selected stations, turbidity and chlorophyll *a* .
3. Surface sediment samples and analyses for heavy metals and organics at 43 stations scattered around the Bay.

In addition to this water column monitoring effort, significant advances have been made through a collaborative program between NOAA NMFS Woods Hole and the RIDEM Fish & Wildlife to develop a standardized template to analyze fisheries management data in a manner that allows sharing of data between the State of R.I. and the NMFS New England fisheries management efforts. In addition, funds have been

provided to the RIDEM Division of Fish & Wildlife to replace the ailing trawler now used for fisheries population data generation.

Much of the water column monitoring for this comprehensive effort is concentrated on issues related to excess nutrients and their impacts, including low dissolved oxygen. Sediment samples for toxics were taken in 1997 and 1998, with chemical analyses completed in late 1998, and six of the water column continuous monitoring probe stations are now operational. Monthly transect sampling cruises of the zooplankton in the Bay have been ongoing since February 1998.

An additional station is expected to be added by RIDEM to the system in Summer 2000 at the Mobil Pier in the Providence River. In addition, a U.S. EPA EMPACT grant to the Narragansett Bay Commission is funding the installation of three sampling buoys to be placed in the Lower Providence River, the Seekonk River, and Mount Hope Bay. The data for this monitoring system will eventually be posted and available to the public on the World Wide Web through the data center at the URI Graduate School of Oceanography.

This collaborative effort will provide an excellent comprehensive picture of the present conditions of various aspects of the Narragansett Bay ecosystem. Through continued funding support, it is hoped that this system will provide a national example of a multi-agency/institution collaborative state-of-the-art monitoring effort that pools the significant marine expertise concentrated in the Ocean State in a highly cost-effective manner.

Early Results of the Bay Monitoring Program

Under the collaborative monitoring program, recent sediment data (1997-98) was acquired for 43 stations in the Bay, providing an integrated picture of recently deposited sediment pollutant loads. In addition, comparison of data from 20 of these stations with data from sediment samples taken for the original Narragansett Bay characterization study (1988-89) (and performed by the same researchers; Drs. King and Quinn, URI/GSO) provide an indication of pollutant loading trends over the last 10 years.

Results from King *et al.* (1998) show major decreases since the 1988-89 samples for trace metal concentrations in all metals analyzed in surface sediment samples taken from the most industrially-impacted areas of the Bay, the Providence / Seekonk tidal Rivers and the Taunton River (Mount Hope Bay). Stations from mid Bay areas showed little change or very minor increases in metals for the recent sampling, and followed the overall pollution gradient noted in the original Bay characterization study: greatest sediment pollution concentrations are always in the most industrialized/urbanized areas (e.g., Providence/ Seekonk Rivers) of the upper Bay, and decrease rapidly as one moves down bay. Measurements of Simultaneously Extracted Metal (SEM) concentrations and Acid Volatile Sulfides (AVS) indicate that the trace metals are not likely to be bioavailable at the stations with highest metal concentrations unless they become oxidized by human activities such as dredging.

The decrease in concentrations of metals in the most polluted stations from the recent (1997-8) sediment data has lowered the upper range seen in surface sediment concentrations for these metals, although highest levels are still nearest the major loading sources (major wastewater treatment facilities (WWTFs) and industrialized river mouths).

This trend of decreasing metal concentrations likely reflects both the success of WWTF pretreatment programs and the decrease in the number of metal discharges from industries such as jewelry and electroplating due to the shift in the global manufacturing economy over the last 20 years.

For all organics analyzed (PAHs, PCBs, OCPs, TPH), concentrations in the surface sediments followed the same gradient as described above, with greatest levels found associated with urban sources and industrialized river mouths in the upper reaches of Narragansett Bay. These organic pollutants also showed a decrease in surface sediment concentrations at many upper Bay stations since 1988-89, and significant decreases at stations closest to WWTF discharges. These results likely reflect the improvement in secondary treatment achieved over the last decade at the major WWTFs, another success story for the federal Clean Water Act, and a strong positive step towards recuperation of these areas as projected by the CCMP if treatment levels were improved at the WWTFs.

In contrast to these results, sediment nitrogen and carbon loads appear to have increased according to King *et al.* (1998), indicating that the Bay is experiencing a continued increase in nutrients and biological productivity response to those nutrients, again emphasizing the concerns over excess nutrient impacts.

Special Monitoring for Hypoxia

In addition to the above monitoring plans, The NBEP organized a voluntary effort during the summer of 1999 to measure overnight decreases in dissolved oxygen across the entire upper half of Narragansett Bay using multi-agency boat teams to cover large areas of the Bay simultaneously. This dissolved oxygen survey included volunteers from the EPA Atlantic Ecology Division Lab, EPA Lexington Lab, the Narragansett Bay Commission, RIDEM Narragansett Bay Estuary Program, Roger Williams University, Brown University, U.S. Fish & Wildlife, URI, Save The Bay, and others. Planning is underway for a monthly evening survey over the summer of 2000; the implementation of this effort is dependent on the availability of needed funding and staff resources.

The goal of the NBEP surveys is to begin first steps towards mapping a sporadic hypoxic zone that is thought to be developing at least once every two years in the upper Bay under specific meteorological conditions. The final goal is to provide data useful to the State in the preliminary ongoing TMDL for excess nutrients, especially nitrogen, to the Providence /Seekonk Rivers.

Trends in Oxygen

In January 2000, the Rhode Island Sea Grant sponsored a symposium on recent research in Narragansett Bay. At that symposium, Dr. Deacutis of the NBEP presented preliminary results on the two dissolved oxygen surveys completed in summer 1999. Results indicated that several open areas of the upper Narragansett Bay and upper West Passage, Mount Hope Bay, and the western side of Greenwich bay show evidence of low oxygen condition (<4.0 ppm) during weak (neap) tides. There appears to be a risk that oxygen levels may go even lower in some of these areas, approaching hypoxic levels (< 2.0 ppm) on a sporadic basis in mid or late summer over parts of the upper half of the Bay.

Such events may be brief (on the order of days), but can have a significant and lethal effect on sensitive bottom species in the Bay. Such events may be contributing to the quantified shift from dominant benthic fish species to a pelagic fish community in Narragansett Bay over the last decade (RIDEM Fish & Wildlife). In addition, work initiated by the NBEP has shown that eelgrass, a critical nursery habitat for young fish and crabs, was at significantly higher abundance historically, but has now been eliminated from most of the upper half of the Bay due to poor water clarity. Scientists agree that the bottom-line driving parameter for both these issues (low oxygen and poor water clarity) is the rapid growth of phytoplankton biomass in the Bay in areas receiving high loadings of nitrogen, both as ammonium and as nitrate. When these plants die, bacterial decomposition uses up much of the available oxygen in the bottom waters on very calm, hot nights in late summer, especially under conditions with even slight density stratification.

This issue is linked to the nutrient control workshop, *Nutrients and Narragansett Bay*, funded and coordinated by the NBEP in September 1998. This workshop brought together technical staff, scientists and policy-makers to discuss nutrient impacts on the Bay and ways that the problem can be addressed. It also provided general technical information on operational procedural changes at major WWTFs which can potentially significantly increase denitrification of the effluent (as presently being done at many Connecticut WWTFs).

The RIDEM WWTF operator's training program and the New England Interstate Water Pollution Control Commission (NEIWPCC) developed a follow-up workshop on June 9, 1999 in Providence titled the *Ocean State Nitrogen Optimization Program for Wastewater Treatment Facilities*. This program provided more specific engineering/operations information on the potential opportunities available to WWTFs to decrease nitrogen loads from their facilities through voluntary alterations in treatment operational procedures.

Proactive efforts in this area have a high likelihood of providing visible improvements in the Bay (e.g., through increased clarity of the water in the upper Bay and possibly decreases in incidence of hypoxia).

This effort to educate WWTF operators has been continued by the RIDEM WWTF operator training program. This program has worked with the New England Interstate Water Pollution Control Commission on an EPA-funded project to examine specific R.I. WWTFs and have experts from other states provide technical advice and insight to the operators of these plants on how feasible such denitrification enhancement treatments are likely to be at their specific plants under present configuration and tank capacities. The potential nitrogen loading decreases projected for some of the plants may exceed 50%.

8. Watershed Projects

Until recently the Department was not utilizing a watershed-based management framework, therefore intensive surface water monitoring was conducted on waterbodies where data indicated existence of water quality problems. Over the past few years the Department has initiated several intensive monitoring projects that are working towards the watershed approach and total

maximum daily load (TMDL) development. Below is a synopsis of the intensive water quality monitoring projects presently being conducted or overseen by the Department.

a. Providence-Seekonk Rivers

The influence of nutrient loadings on eutrophication in the Providence and Seekonk Rivers is being addressed through a RIDEM study of the area. Information to date points to excessive nutrient loadings from WWTFs discharging to the Providence, Blackstone and Pawtuxet Rivers causing high phytoplankton levels and resulting low dissolved oxygen levels in the Providence and Seekonk Rivers. A study characterizing source loadings and the present condition of the system was performed by RIDEM during 1995 and 1996. A review of the model proposed for the area was completed in 1998 with the recommendation that additional testing of the model equations be conducted through a comparison with the results of a controlled experiment. The comparison, completed in March 2000, documented the performance of the model using a new set of relations for phytoplankton growth.

The nutrient TMDL is scheduled for completion at the end of September 2001. RIDEM is in the process of procuring consulting services to calibrate the hydrodynamics and water quality models for the area. Barring excessive delays in contracting, this process will be completed by December 2000. Alternative reduction scenarios will be simulated during the winter and spring of 2001, and the draft TMDL document will be issued for public comment during the summer of 2001.

RIDEM is also working with a public relations consultant to develop a public outreach strategy on nutrient issues in the Providence River and upper Bay. The consultant is working on approaches to inform the public about the current impairment of the Bay, of the benefits to plant and animal communities in the Bay, and of the benefits to the citizens of Providence metropolitan area.

b. Barrington-Palmer-Warren River Estuary System

The Barrington and Palmer Rivers are impacted by fecal coliform loadings from their principal tributaries during dry and wet weather. The lower Palmer River is additionally listed as impaired for nutrients. RIDEM studies characterized causes and impairments through wet and dry weather studies of the area during 1995-1998. The draft TMDL for the Barrington River was completed in May 2000, and accompanied the Runnins River fecal coliform TMDL. The Barrington TMDL was based on the predictions of a water quality model which set loading goals for the Runnins during summer dry and wet weather conditions. The model demonstrated that the Barrington River will meet its design use of unconditional shellfishing in Shellfish Growing Area 2 if loading targets are met in the Runnins River. A similar study will be completed in the Palmer River during the fall of 2000. The Palmer River is the largest bacterial source in dry and wet weather. Field sampling by RIDEM and Massachusetts agencies has linked the problem to agricultural uses in Massachusetts.

The Palmer River is also affected by excessive nutrient loadings. These loadings produce high seaweed accumulations that cover the bottom of the lower River, which in turn cause large fluctuations in dissolved oxygen in the River, with supersaturated daytime levels and low night-time levels. The condition appears to result from a combination of shallow water depths in the lower Palmer River and nutrient loadings from permitted discharges in downstream reaches of the Warren River. RIDEM is scheduled to complete a nutrient reduction TMDL for the Palmer River in mid-2001.

c. Woonasquatucket River

As part of the "Special Place" Initiative Program, EPA has committed to assisting RIDEM with several tasks within the Woonasquatucket River Watershed. These tasks include locating, investigating and eliminating dry weather discharges, developing strategies address non-CSO wet weather discharges to the river, conducting targeted NPDES and compliance oriented inspections, and working with local governments and citizens groups to permanently protect riparian buffers and other critical land areas. Initial and follow-up reconnaissance of dry weather discharge pipes has been completed thus far. Drain pipes identified as probable pollutant sources during initial surveys are slated for additional monitoring and investigation during 2000. Targeted inspections of permitted NPDES dischargers and selected auto salvage/recycling yards are being scheduled for the summer of 2000. Proposals for water quality and habitat restoration projects are currently being solicited from local government, nonprofit and stakeholder groups, and considered for funding.

Other monitoring efforts are also proposed for the Woonasquatucket River during the summer of 2000. RIDEM has begun the Woonasquatucket River TMDL study to address fecal coliform, metals, and nutrient impairments. The Louis Berger Group has been contracted to assemble relevant existing water quality data for the watershed, summarizing present water quality conditions, and identifying a monitoring plan to be conducted during 2000 and 2001. RIDEM is assisting EPA and the Narragansett Bay Commission in the planning of wet weather monitoring studies to bracket wet weather sources of metals and bacteria during the summer and fall of 2000.

d. Narrow River

RIDEM began studies of the Narrow River watershed during 1999 to address violations of water quality standards for fecal coliforms during dry and wet weather. Field studies conducted during dry weather located three areas of concern along the River. Followup investigations have identified possible sources as failed ISDS's and an outhouse for two of the problem areas. Additional analysis of the third impairment indicates that local waterfowl could be the source of the third impairment. The 1999 field studies also documented fecal coliform loadings in runoff from the heavily developed neighborhoods along the River and the impact of these loadings on levels in the River.

The Narrow River TMDL is scheduled for completion at the end of September 2000. The TMDL staff is presently working to ensure that followup

actions are taken by Compliance to identify and remove the dry weather sources. The TMDL staff is also working with the local citizens' group, the towns, and other State and Federal agencies to establish structural and non-structural solutions to eliminate sources of the impairment. These include identifying additional stormwater BMP sites and appropriate treatment technologies and devising strategies that will eliminate waterfowl and pet waste as sources.

e. Hunt River

In 1996 and 1997, URI conducted an extensive water quality monitoring project for the Hunt watershed. URI collected water quality data from 22 sites within the watershed . The URI study was divided into two phases: a preliminary site assessment (dry weather water quality monitoring program) and a wet weather characterization. Violations of the fecal coliform bacteria standard were documented, under both dry and wet weather conditions, at several locations along the Hunt River mainstream and its tributaries. Dry weather dissolved oxygen concentrations met the standard of 5.0 mg/L at all stations, with the exception of violations at the most upstream stations in Sandhill and Frenchtown Brooks.

In 1999, RIDEM staff conducted supplemental monitoring in the Hunt River watershed to support the development of fecal coliform TMDLs for the Hunt River and Fry and Scrabbletown Brooks. This effort included ambient monitoring for fecal coliform at 34 sampling stations located along the mainstem of the Hunt River and many of its tributaries. Dry weather samples were collected from three to eight times at each station during the spring, summer, and fall of 1999. Wet weather samples were collected during two storm events.

RIDEM's water quality assessment found that most of the Hunt River and its tributaries do not fully support the designated uses for either Class A or Class B waterbodies during either dry or wet weather conditions. However, wet weather impacts were found to be very important. RIDEM identified 4 major wet weather sources of fecal coliform in the Hunt River watershed: stormwater runoff, resident waterfowl, a dairy farm, and roosting pigeons at a highway overpass. TMDLs are underway to address the sources and should be completed in the summer of 2000.

f. Portsmouth/Island Park

The Island Park and Portsmouth Park areas have chronic sewage contamination problems. Shellfishing is banned from adjacent waters due to the presence of high concentrations of fecal coliform bacteria in both dry and wet weather storm drain flows. As a result, these areas were selected for a two-year study conducted by RIDEM from 1996 to 1998. The project, entitled "The Development and Implementation of Methods to Identify Fecal Coliform Contamination of Storm Sewers," focused primarily on developing a standard method to identify sources of bacterial contamination in polluted areas.

In Portsmouth Park, the locations of bacterial contamination to storm drains and hidden shoreline pipes were determined through dye tests. The dye test candidates were conducted when disproportionate water use was calculated for a home's lot size and soil type. In Island Park, a number waterfront lots were

discovered to have hidden pipes in the sand and rocks of the cove. Homes set back one or more lots from the shore failed to show any evidence of excessive sewage application rates on the ground's surface, presumably due to the rapidly drained soils. It is suspected that plumes of poorly treated sewage are created and discharged to The Cove.

The 1998 RIDEM Draft Project Report concluded that the Portsmouth Park storm drainage network discharges sewage-contaminated groundwater directly into the Sakonnet River. The draft report recommends calculating a wet weather flow rate estimate and conducting further monitoring to accurately assess fecal pollution loadings from the storm drain systems.

g. Saugatucket River

In 1995, RIDEM contracted with URI's Civil and Environmental Engineering Department to conduct a water quality assessment of the Saugatucket River watershed. The project was conducted over a two-year period from 1996 to 1997. The intent of the project was to assess point and nonpoint sources of pollution to the river, with the results of the assessment being used to calibrate and validate a water quality model. Three wet and three dry weather surveys were completed. In addition, URI carried out targeted monitoring in an effort to locate nonpoint source "hot spots" of bacterial contamination. RIDEM received a draft final report from URI in February 1999.

The draft final report found that, during dry weather, the fecal coliform concentrations are elevated at several locations in the River and two of its tributaries, Indian Run and Mitchell Brook. A short stretch of river in the Peace Dale Mill complex was found to contain a major source of bacterial contamination, but no discrete source was ever identified, despite repeated attempts. In wet weather conditions, several stations along the river violated standards, as well as locations in Indian Run and Rocky Brook.

The dry weather data was used to calibrate a QUAL2, steady state model of the River. The model included a number of nutrient, dissolved oxygen, and biological parameters. The model results, combined with the monitoring data, clearly indicate that there are dissolved oxygen problems in Saugatucket and Wakefield Ponds. Saugatucket Pond receives elevated ammonia and nitrate loadings, probably from the Rose Hill Landfill, and the Wakefield pond receives remnants of the ammonia decay from the upstream Saugatucket Pond. The model indicates that the two ponds suffer from an increasing nutrient enrichment due to the nitrogen loadings, leading to a strong accumulation of biomass. This biomass remains in the ponds and leads to a high sediment oxygen demand.

RIDEM is currently developing a number of TMDLs to address various impairments in the Saugatucket River watershed. Supplementary monitoring is planned for the summer of 2000. The TMDLs are expected to be finalized in 2001.

h. Blackstone River

In 1993, RIDEM received a 104(b)(3) grant to investigate the need for Tier II stormwater permits in the Blackstone River Watershed, target industrial facilities in the watershed for with RIPDES stormwater regulations, and conduct outreach and site visits for those facilities. The initial work (i.e., Phase I) involved analysis of data available from the general permit database for facilities in the Blackstone River watershed. The need for additional monitoring requirements to provide supplemental data for storm water discharges associated with industrial activity in the watershed, was determined. In addition, review of the wet weather data, modeling efforts, and estimates of storm water contributions from the Blackstone River Initiative (BRI) was conducted.

In 1999, RIDEM used the remaining project funds to contract with the Blackstone Valley Community Pollution Prevention Project (BVCPPP) to conduct a second phase of the Blackstone stormwater project. Using the list of unpermitted facilities in the draft report, as well as other available information, BVCPPP targeted industrial facilities for compliance with RIPDES stormwater regulations. Letters were sent to targeted facilities discussing the potential impacts on the river from their uncontrolled stormwater runoff and the need to develop a Stormwater Pollution Prevention Plans. Permission was also requested to conduct a site visit. Facilities agreeing to a site visit by BVCPPP staff received site assessments to identify potential sources of stormwater pollution. A final report detailing the results of both phases of the project is to be developed, and the project completed, by the end of FY2000.

The results of the stormwater study will be combined with the results of the BRI to support the development of a number of TMDLs addressing impairments along the Blackstone River. RIDEM intends to conduct supplementary monitoring during the summer of 2001.

9. Citizens' Volunteer Monitoring

Citizens' volunteer monitoring has become an important environmental monitoring force within Rhode Island. Its popularity is reflected in the growing number of citizens' volunteer monitoring groups and in the increased number of volunteers and monitoring stations being added to existing citizens' monitoring groups.

RIDEM is represented on the Rhode Island Volunteer Monitoring Steering Board which is an advisory board that oversees volunteer (citizen) monitoring activities around the state. The board facilitates communication between individual citizen groups and has strengthened communication between citizen groups and the state and federal agencies which use their data. Since RIDEM no longer has a fulltime Citizen Monitoring Coordinator position, representation on this board has assisted RIDEM in maintaining an outreach approach with these groups.

The OWR utilizes the data collected by the various Citizen Monitoring groups in the water quality assessments conducted for the 305(b) report. Furthermore, the monitoring data is used as a screening tool to alert the OWR to problem areas where the

Department needs to conduct sampling and take action.

10. Quality Assurance

Environmental Protection Agency (EPA) policy requires participation by all EPA regional offices, program offices, EPA laboratories, and states in a centrally managed Quality Assurance (QA) Program. As part of the QA Program, each state is required to develop a QA Program Plan and QA Project Plan(s) for assuring the reliability of monitoring and measurement data. The OWR has developed a QA/QC Plan for the Office. In addition, QA Plans are developed for various projects conducted by and for the OWR. Recently, as part of the Performance Partnership Agreement requirement, the OWR has participated in Departmental meetings to assist in the development of a Departmental QA/QC Plan.

11. Data Management

The OWR has expended great efforts over the past several years to improve the data management capabilities within the office. Major improvements in both hardware upgrades and purchases of various software have been accomplished. An Access database has been developed to house water quality data and information. This database has been constructed to be compatible with both the RI WBS Access database of assessments and EPA's STORET.